Local Unpaved Road Surface Management in Indiana

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INTRODUCTION

The term "unpaved" describes road surfaces of natural earth, unimproved, graded and drained; gravel or stone, and so on. Most roads without bituminous, cement concrete or brick surfaces may be described as unpaved. In Indiana, 1982 county road statistics showed that out of a total road mileage of 68,297 miles (109,958 km) maintained by the 92 counties, 2% was unimproved or graded and drained, 39% gravel or stone surface, and the remainder paved. Over 40% of the roads maintained by 53 counties is unpaved and the maintenance responsibility of 59 counties includes at least 200 miles of unpaved roads (Table 1) [1].

TABLE 1 Distribution of Unpaved County Roads in Indiana

Percent Unpaved In County	Number of Counties with Total Mileage Unpaved				Total
	< 100	100 - 199	200 - 499	> 500	
Less than 40%	12	17	10	—	39
More than 40%	—	4	36	13	53
Total	12	21	46	13	92

The above statistics confirm unpaved roads as an essential component of county road surface management in Indiana.

The Federal Highways Administration (FHWA) defines road surface management as the application of pavement management practices to the needs of local governments including management of light-type pavements and unpaved surfaces [2].

This paper describes existing county road maintenance management practices, road condition assessment and costs and presents a procedure for unpaved road surface management in counties, which can also be applied by other local agencies such as cities, towns, and so on.

CURRENT COUNTY UNPAVED ROAD SURFACE MANAGEMENT PRACTICE

Unpaved road surface management in each county is usually a reflection of the prevailing system of management for the whole network. Most counties have an informal approach to road surface management (RSM) the major component of which is maintenance. Thus, maintenance management procedures are most important in any road surface management proposed for local county highway networks. The National Association of County Engineers (NACE), through its Action Series [3] set up some maintenance management procedures but no Indiana county has applied them directly [1].

County unpaved road maintenance activities include mainly dragging, blading, grading, addition of gravel, snow plowing and to some extent, side ditch clean up and cutting and other drainage works. Other activities such as dust control, brushing or spraying, mowing, culvert maintenance and replacement, and sign maintenance are variable and depend on availability of money and the road condition.

Most county highway departments seldom collect and document on a continuous basis, quantitative data on road condition, traffic volume or accidents for road maintenance management. In a few cases only, specific traffic volume data have been obtained to provide justification for major improvement projects such as paving of gravel or stone roads. HERPICC currently organizes a traffic equipment loan scheme as part of FHWA's Rural Technical Assistance Program (RTAP) which has been patronized by some counties and cities. Most decisions for road maintenance or improvement are based at present, on local experience only and citizen complaints are a major consideration in assigning maintenance priority. As a result, for unpaved road surfaces, a blanket blading frequency may be adopted for all roads because citizens on some low-volume roads demand equal treatment. The question is, can local unpaved road surface management be organized or planned effectively?

COUNTY ROAD MAINTENANCE COSTS

The highway cost accounting and budgeting procedures established by the Indiana State Board of Accounts was a first step towards organizing county highway management. Although suggestions are made in the Cost Accounting Guide Manual [4] for the organization and planning of maintenance activities, few counties adopt the procedures completely. The mandatory annual reports provide revenue and expenditure information for each state or federal revenue fund under four main expense account categories — administration, maintenance and repair, construction or reconstruction and general and undistributed expenses.

Information on the percentage of maintenance expenditure (average 1980-1983) for cost items in the annual reports of the five study coun-

ties, is presented in Figure 1. The items are administrative and mechanical overhead, equipment operation, stone or gravel, bituminous and other materials, labor and contractual services. The information in Figure 1

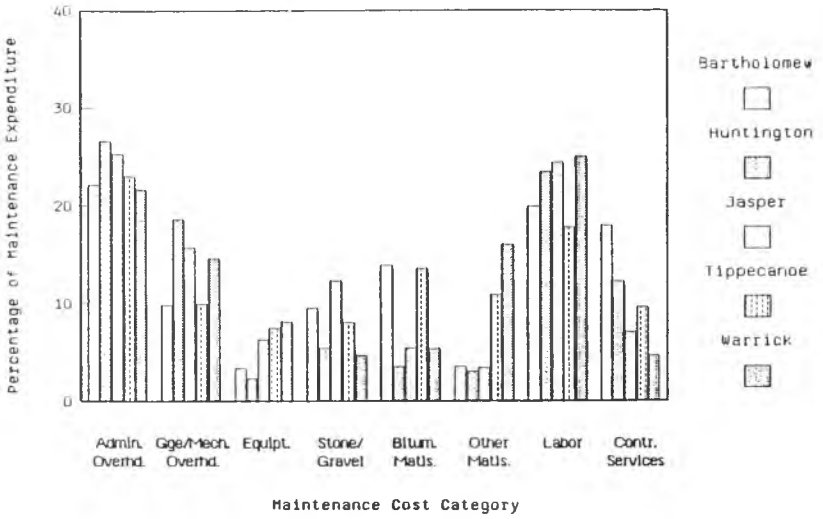

Figure 1. Percentage of County Highway Maintenance Expenditure (Based on Average 1980-1983 Costs by Category)

is suitable for highway resource management, and that is only a portion of road surface management. For effective road surface management, costing should best be done by maintenance activity and related to road surface type and possibly location. Unit cost of maintenance and repair, calculated from the cost information for all roads, independent of surface type, ranged from $990 to $2310 per mile. The variation in unit maintenance cost between counties appear to be related to the revenue received rather than a function of county mileage responsibility.

UNPAVED ROAD MAINTENANCE COSTS

Specific unpaved road maintenance cost information was obtained from data collected separately on selected road sections in five counties [5,6]. Data from four of the five study counties (Bartholomew, Huntington, Jasper and Tippecanoe) gave average 1983 county annual cost per mile of $260, $751, $809 and $273 for the four counties respectively. Unit maintenance cost for Tippecanoe County covers blading and grading only. The additional activities included in the cost for the other three counties are shown in Table 2. Information for Huntington County was calculated from summaries obtained from its maintenance management system. The addition of the cost of other activities in Jasper and Hun-

tington Counties resulted in higher annual maintenance costs above $700 per mile.

EFFECT OF COUNTY MANAGEMENT PRACTICES ON UNPAVED ROAD MAINTENANCE COSTS

The specific management practices investigated included frequency of blading or grading, type and age of grader or blading equipment, annual addition of gravel or spot regraveling. Effect on unpaved road condition, of various roadway factors was also investigated separately.

Grading Frequency

The cost per mile for blading and grading alone for the four counties ranged from $49 to $433 (Table 2). The low annual grading costs

Table 2 Unpaved Road Maintenance Cost/Mile in Study Counties

ACTIVITY	UNIT	COUNTY B	H	J	T
—	Miles	10.5	260	23	343
Grading	Freq	6	10	21	16
	$ / mi	49	317	433	273
Regraveling	Tons/mi	34	—	63	—
	$ / mi	210	93	193	—
Vegetation	$ / mi	—	92	150	—
Snow Plowing	$ / mi	—	88	33	—
Drainage	$ / mi	—	110	—	—
Sign Repair	$ / mi	—	51	—	—
Total	$ / mi	259	751	809	273

in one county results from lower grading frequency (6 times a year) and a low grader operating cost of $11.14 per hour. Grader operating costs should normally include depreciation costs but this was not included in this case. The cost of overhead may also increase the given grading cost as happens with Huntington County data that incorporated overhead.

Figures 2 and 3 show that in two out of three counties (Huntington and Jasper), logical relationships were found between frequency and traffic volume while no relationship was found for the Tippecanoe County data in Figure 4. The latter county adopts a blanket policy of grading every road about once a week at the discretion of grader operators. There appears to be little or no direct consideration for traffic volume and level of service. Table 3 presents information based on the Huntington County curve, which provides an initial basis for determining grading frequency for various ranges of traffic volumes. Modifications are suggested to account for the effect of sloping sections of roads with rolling to hilly ver-

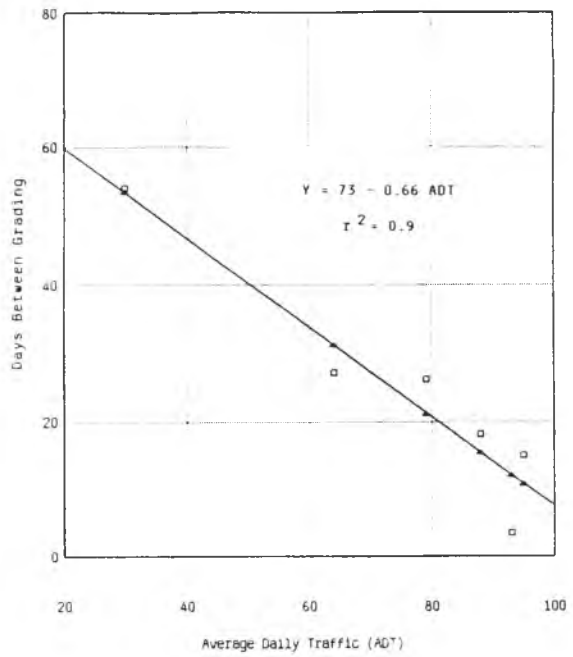

Figure 2. Frequency of Grading vs. Traffic Volume — Huntington County

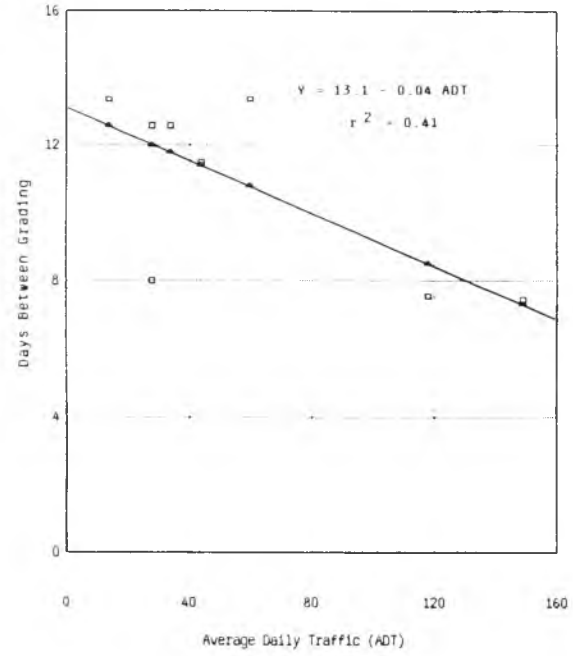

Figure 3. Frequency of Grading vs. Traffic Volume — Jasper County

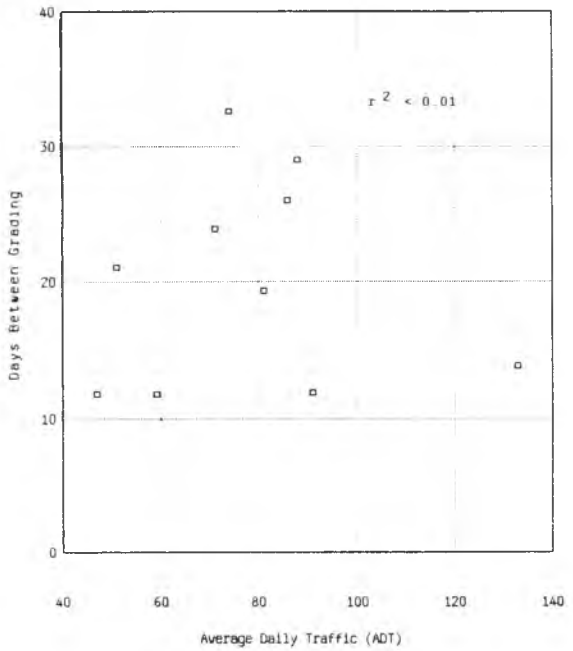

Figure 4. Frequency of Grading vs. Traffic Volume — Tippecanoe County

tical alignment or for roads with frequent driveways and intersections. Such locations were found to be prone to develop corrugations more quickly [5].

Type and Age of Equipment

In one county, trucks with underbody blades were found to be much cheaper to operate and equally effective for routine blading of gravel or stone roads, as motor graders. The unit operating cost (including overhead) for the truck was calculated as $13.4 per hour compared to $28.7 per hour for a motor grader. In another county, age of equipment was found to influence costs so that, average unit operating cost (grader + operator) for motor graders purchased between 1972 and 1974 was $14.6 per mile (grading 17 times a year), compared to a $16.6 per mile (grading 16 times a year) for motor graders purchased between 1980 and 1982. The slight increase in unit cost for the newer equipment was attributed to higher depreciation costs.

Addition of Gravel or Stone

Addition of gravel or stone or spot regraveling is usually undertaken on unpaved road surfaces after the spring thaw. Gravel added to individual road sections in the study counties ranged from 8 tons/mile or 1 truck load (5 cu yd) to 183 tons/mile (about 24 truck loads). Unit gravel

TABLE 3 Suggested Grading Frequency for Various ADT Ranges, Likely Costs per Mile and Other Actions

Traffic Volume (vpd)	Grading Frequency Days Between	(Times/Yr)	Annual Cost/mi	Remarks
< 50	40 - 60	(7 - 5)	$150 - 108	Roads with steep grades Frequent Corrugation may require maximum freq.
50 - 100	21 - 40	(13 - 7)	$280 - 150	Same as above including locations with frequent driveways
100 - 200	7 - 20	(40 - 13)	$860 - 280	Same as above some dust control may be required
> 200	7 or less	(> 40)	> $860	Same as above. Consider stabilization or Paving

or stone costs ranged from $42 per mile to $585 per mile. The amount of spot regraveling adds significantly to the total annual cost of gravel or stone road maintenance. In Mason County, Washington State [7] which uses a maintenance managment system, regraveling was increased and grading frequency reduced to six times a year as a gravel road maintenance policy. A knowledge of the rate of gravel loss is a good indicator of graveling needs. A Rule of Thumb is that there is an annual loss of depth of 1 in. per mile for every 100 vehicles per day of traffic volume on the road [8]. A 4-in. depth of gravel initially provided on a road carrying 100 vpd would last about 4 years. In one county, it was estimated that the amount of gravel required to provide 3 in. of depth over a 20-ft. roadway, would cost about $4,260 per mile. For the 260 unpaved road miles maintained by the county, an annual budget of over $1.1 million would be required for regraveling alone if that level of activity is maintained. Owing to budgetary limitations faced by counties, spot regraveling of problem locations only, provides a lower cost alternative. A good crust should be maintained during blading operations to assist in minimizing regraveling cost.

CONDITION EVALUATION OF UNPAVED ROADS

The condition evaluation of unpaved roads in the HERPICC study [5] was based on three main parameters — roughness, in-situ strength or compaction (Clegg Impact Value), and measured distress (ruts and corrugation). Methods applying both pavement serviceability based on ride comfort (0-5) and measurements using a PCA roadmeter were found to be equally acceptable for evaluating unpaved road roughness. However, obtaining a roadmeter on a regular basis for the average county or city may be a problem since the Division of Research and Training of IDOH operates the only equipment in the state. Although potholes and corrugations may be visually evaluated, some field measurements may be necessary to quantify such measures. Average rut depth can also be measured independently if so desired. The Clegg Impact Value is a useful indicator of the compaction or strength of the surface material.

An increase in coarseness of the surface material was found to result in an increase in measured roughness (counts/mile) and average rut dept (in.). Coarseness was measured using two parameters — fineness modulus (FM), defined as the sum of cumulative percent of material retained on sieve sizes from ¾ in. to #100, divided by 100, and a measure of the equivalent sieve size in inches, which passes 95 percent of the material (D95). Percent passing mid sieve sizes #10 and #40 had a negative correlation with the two condition parameters hence, an increase in those values may reduce roughness and average rut depth. The percent passing #200 sieve and road width were positively correlated with CIV. This indicates that road surface materials with large values of the two

parameters would tend to record higher average CIV values. Average Daily Traffic (ADT) had a positive correlation with roughness although the direct effect on the other condition parameters was not significant. Table 4 presents the average road surface, gravel or stone and cross-sectional characteristics of test sections in the five study counties and Table 5, the characteristics of corrugations measured in three counties. Utilizing Panel Condition Rating (PCR) and equivalent PSR (AASHO) rating, average rater speed on the section and roughness number measured at 20 mph, Table 6 provides a basis for deciding on maintenance or rehabilitation options for unpaved roads.

Condition of unpaved roads changes rapidly, hence condition measurement should relate to immediate maintenance needs. More detailed condition assessment should be required when major rehabilitation is desired. Blading and grading has an immediate effect on the roughness and other measurements. Unpaved road roughness number has been found to reduce by as much as 50% or more after grading [5,9]. A sound blading and grading policy is the most important first step in establishing

TABLE 4. SUMMARY OF AVERAGE COUNTY ROAD SURFACE GRAVEL AND CROSS-SECTIONAL CHARACTERISTICS.

Variable Description	Material Property of Cross-Sectional Characteristic by Study County				
	Bartholomew	Huntington	Jasper	Tippecanoe	Warrick
Number of Sections of Road	5	12	12	12	9
Fineness Modulus	4.4	3.5	4.0	3.9	4.9
Liquid Limit (Range)	13 (12.5-14)	13 (12-14)	11 (7-15)	12 (7-17)	17 (14-20)
Roughness (Counts/Mile)	2858	958	2819	2012	3369
Roadway Width (in.)	16.3 (0.9)[1]	19.2 (1.5)	19.1 (2.3)	19.1 (1.6)	20.4 (3.8)
Camber (%) (Range)	3.4 (.7)[1] (2.3-4.7)	2.8 (.9) (1.4-4.7)	2.8 (.9) (.8-4.1)	4.5 (1) (2-6)	3.84 (1.4) (.6-6.2)

NOTES

[1]Numbers in parentheses are standard deviation values

TABLE 5. SUMMARY OF AVERAGE CORRUGATION CHARACTERISTICS ON SELECTED ROAD SECTIONS IN THREE STUDY COUNTIES

Variable Description	Jasper County Road Sections				Huntington County Road Sections			Warrick County Road Sections	
	Div #1	Div #2	400W	780W	300E # 1	300E #2	100N	900W	475W
Crest CIV	33	28	37	52	52	50	42	47	63
Trough CIV	37	41	34	36	41	45	56	49	64
CIV on Road	49	45	35	54	54	50	46	60	86
Wavelength (in.)	26	35	22	29	19	18	17	32	48
Depth (in.)	1.25	.875	1.0	0.8	.625	.875	.75	.75	1.0
Location[1]	Int	Int & SL	Int	Int	Int & SL	SL	DW	SL	SLC
Length	150 ft	130 ft	150 ft	120 ft	180 ft	250 ft	150 ft	200 ft	300 ft

NOTES

[1]Location Description: Int = Intersection; SL = Slope; SLC = Downslope before a sharp curve; DW = Location with frequent driveways

TABLE 6. SUGGESTED RSM OPTIONS FOR VARIOUS ROAD CONDITION LEVELS

PCR(PSR)	SPEED (mph)	ROUGHNESS (Counts/Mile) B*	J**	T***	MANAGEMENT OPTIONS
1.5 (3.5)	>40	—	—	500	No Maintenance
2.0 (3.0)	>40	1000	1500	1250	Blading
2.5	36	2000	3100	2100	Grading
3.0 (2.0)	30	3000	—	2900	Heavy Grading and Regraveling if Required
3.5 (1.5)	<28	4000	—	3700	Regraveling
4.0 (1.0)	<26	5000	—	4600	Rehabilitation (Condition Survey)

NOTES

*Representative of Southern Conuties with Rolling to Hilly Terrain (Typical Material Used is Indiana No. 5, 8 or 9)

** Unstable Subgrade Soils of Muck or Peat

*** Representative of North/Central Counties with Flat to Rolling Terrain (Typical Material Used is Indiana No. 53 or 73)

unpaved road surface management. Data in Table 3 is an initial basis for establishing blading and grading frequencies. However, grading frequencies should be increased for some road sections with hilly or rolling vertical alignment, curves, frequent driveways and near intersections owing to the tendency to develop corrugations (Table 5).

Suitable gravel or stone surface material specification is also essential for good unpaved road performance. After a study of gradation characteristics of surface gravel or stone materials (with good performance in five counties), a gradation band was suggested for improved performance of unpaved road surfaces in Indiana (Figure 5). The gradation band was selected from the range of gradation bands presented by FHWA [10,11] because it is the best representation of the range of material gradation of gravel or stone roads with acceptable performance in the study. Additional individual county gradation curves observed in the research study are presented in a separate report [5].

IMPLEMENTING UNPAVED ROAD SURFACE MANAGEMENT IN INDIANA

Unpaved road surface management (URSM) cannot be undertaken in isolation but only as a part of the total road system management. Figure 6 presents a basis for gradual transition from current county road management procedures to a complete road surface management in any Indiana

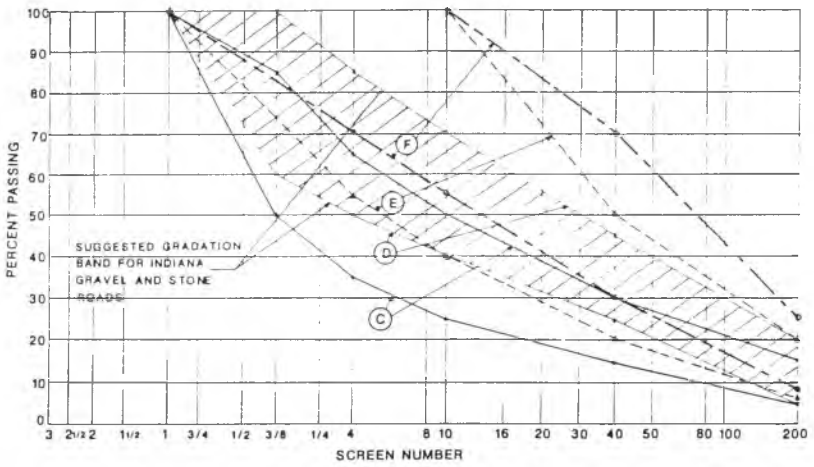

Figure 5. FHWA Gradation Specifications for Surface Gravel Showing Suggested Gradation Band for Gravel Road Surface Material in Indiana

county. The progress through the stages depends on individual county capability and administrative resources. Because RSM depends on reasonably accurate costing of maintenance activity and other road projects, development of a good data base is an essential part of RSM. For the average county in Indiana, simple changes in the Daily Work Report Form has been suggested to enable accounting by maintenance activity and by location or at least, by road surface type [5]. However, both training and staff motivation may be necessary in some counties to successfully undertake an RSM.

The following preparatory activities would help the successful implementation of RSM in local areas.

1. Classification and demarcation of road sections: A good road map with sections well marked, numbered or named would suffice initially. Otherwise, roads with consistent characteristics can be numbered logically and demarcated as road sections.
2. Road inventory: Starting with higher functional classes of road, local authorities can begin by updating road inventory information maintained by the Division of Planning, IDOH by conducting additional field observations, if necessary.
3. Traffic counts or good initial estimates of traffic volumes, will be required for differentiating between the level-of-service of roads in the jurisdiction.

Steps in Unpaved Road Surface Management

The most important aspect of URSM is the ability to accurately cost maintenance activities by road surface type and preferably by road sec-

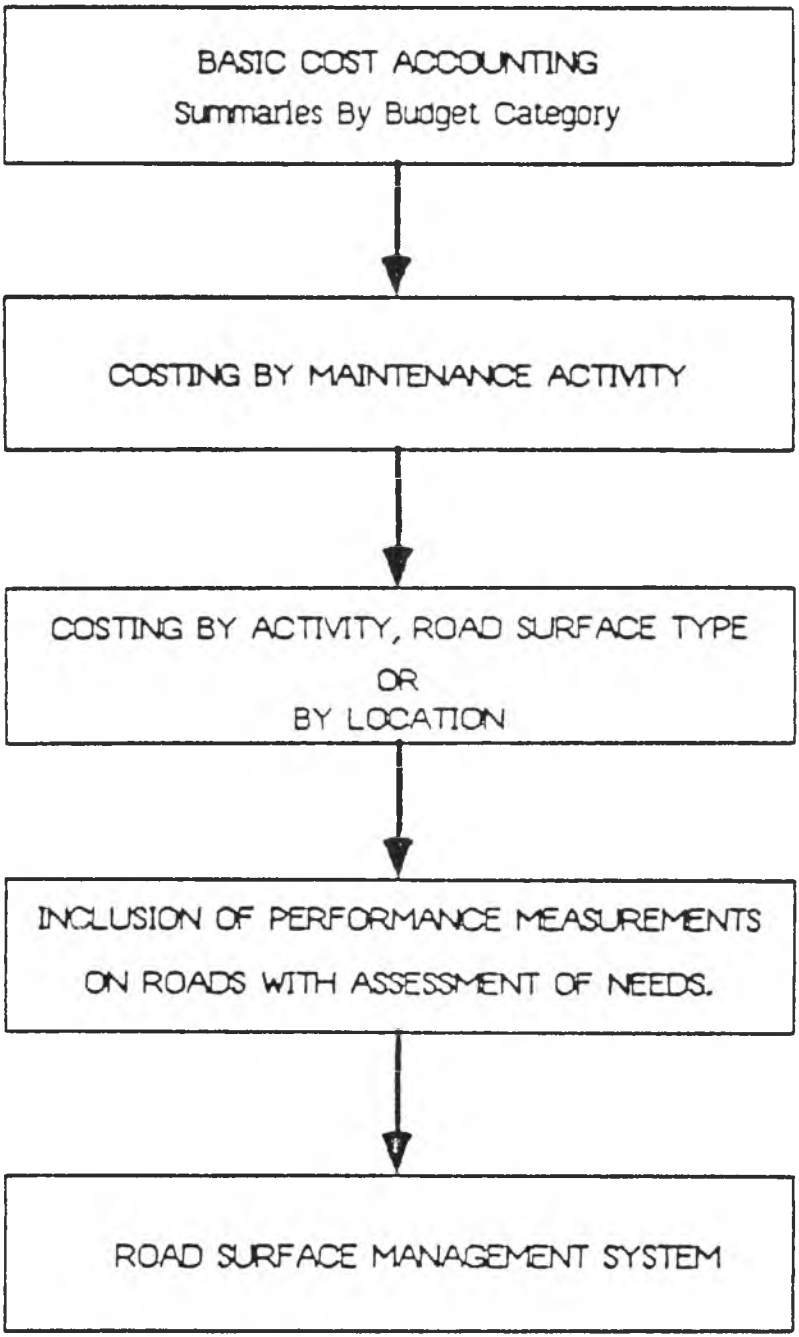

Figure 6. Stages of Road Surface Management System Development in Individual Counties.

tion location. Tradeoffs between the cost of unpaved road maintenance activities such as blading or grading and regraveling, or unpaved road maintenance and paved road maintenance, provide a useful basis for making decisions relating to increase in maintenance levels or rehabilitation. Updating information provided in Table 3 to suit local conditions provides a good basis for determining blading or grading frequences and hence, the cost of such operations.

The following are suggested as essential steps for unpaved road surface management (URSM).

1. Specify grading frequencies based on classification and traffic volume and determine spot regraveling needs.
2. Undertake maintenance as planned and monitor maintenance activity cost using modified cost accounting procedures.
3. Monitor road condition after spring thaw and also in summer through routine inspections observing distress development and ride comfort.
4. Review Step 1 and evaluate road performance based on estimated costs and condition. Consideration should be given to any planned changes in level-of-service for roads under consideration.
5. If rehabilitation, including paving of the gravel surface is required, a more detailed condition survey would be necessary to determine exact needs and cost.
6. Ensure a combined RSM system by coordinating unpaved road maintenance activities and programs with those determined for paved roads in the network.

SUMMARY

Although this paper considers unpaved road surface management, the modified cost accounting procedure based on maintenance activity costing, considers all road surface types. However, road condition assessment would differ in detail for paved and unpaved surfaces. For most counties, the most appropriate first step towards RSM would be the adoption of a system of maintenance activity costing covering all roads. The steps outlined above would further enhance the ability of local agencies to adequately manage and maintain unpaved roads in their road network.

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